

# Cardiac Auscultation

Mark Haigney, MD  
[mhaigney@usuhs.edu](mailto:mhaigney@usuhs.edu)



# Overview

- Lecture
  - Normal and abnormal sounds
  - Mid-systolic murmurs
- Friday
  - Holosystolic murmurs
  - Diastolic murmurs
  - Unknowns
- Monday
  - Review
  - Live patient CV exam





# sound

- Vibrations with multiple features
- Duration
  - Prolonged= murmurs
  - Instantaneous= heart sounds
- Frequency
  - Massive structures give low frequency sounds
  - Low mass/high energy gives high frequency
- Intensity
  - Greater energy/proximity gives greater intensity
  - Fourth power of velocity
- Radiation- sounds reflect backwards, murmurs travel forward





# stethoscope

- Typically has bell and diaphragm
  - Bell for low frequency
  - Diaphragm for high
- Angle the ear pieces pointing toward your nose



# First Heart Sound

- S1 generated by closure of AV valves
  - Mitral
  - Tricuspid
- Medium to high frequency
  - Heard all over precordium
  - Heard best with diaphragm in LLSB and apex
- Mitral valve closes before Tricuspid
  - Splitting of S1 audible in majority of subjects
  - *Don't be fooled into thinking a split S1 is an S4*



# Intensity of S1

- Loud S1
  - Stiff valve
    - MITRAL STENOSIS
  - Rapid rise in LV pressure
    - Exercise, hyperdynamic state
  - Short PR interval
    - MV wide open when LV pressure starts rising





# Intensity of S1

- Soft S1
  - Very stiff valve
    - Severe MITRAL STENOSIS
  - Decreased energy
    - Failing left ventricle
  - Long PR interval
    - MV has drifted closed and so doesn't move much with LV systole





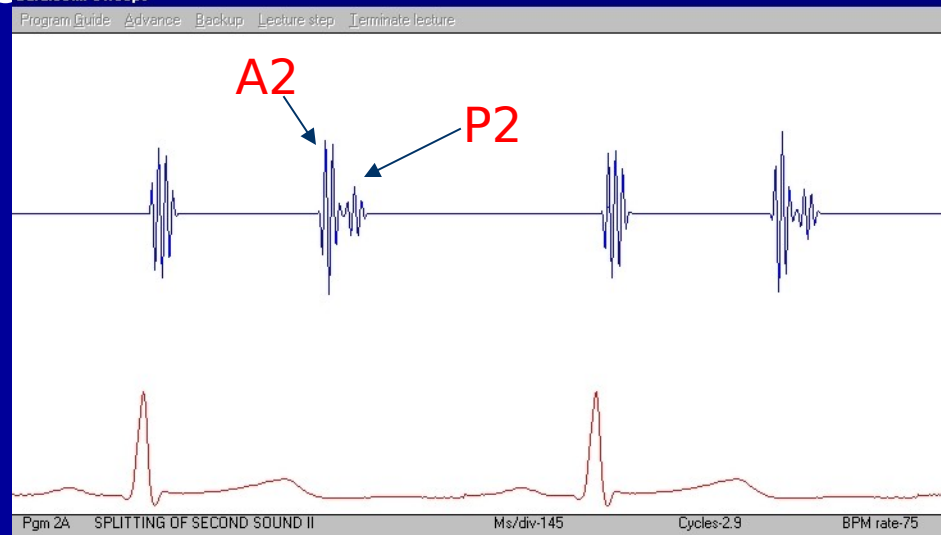
# Second Heart Sound

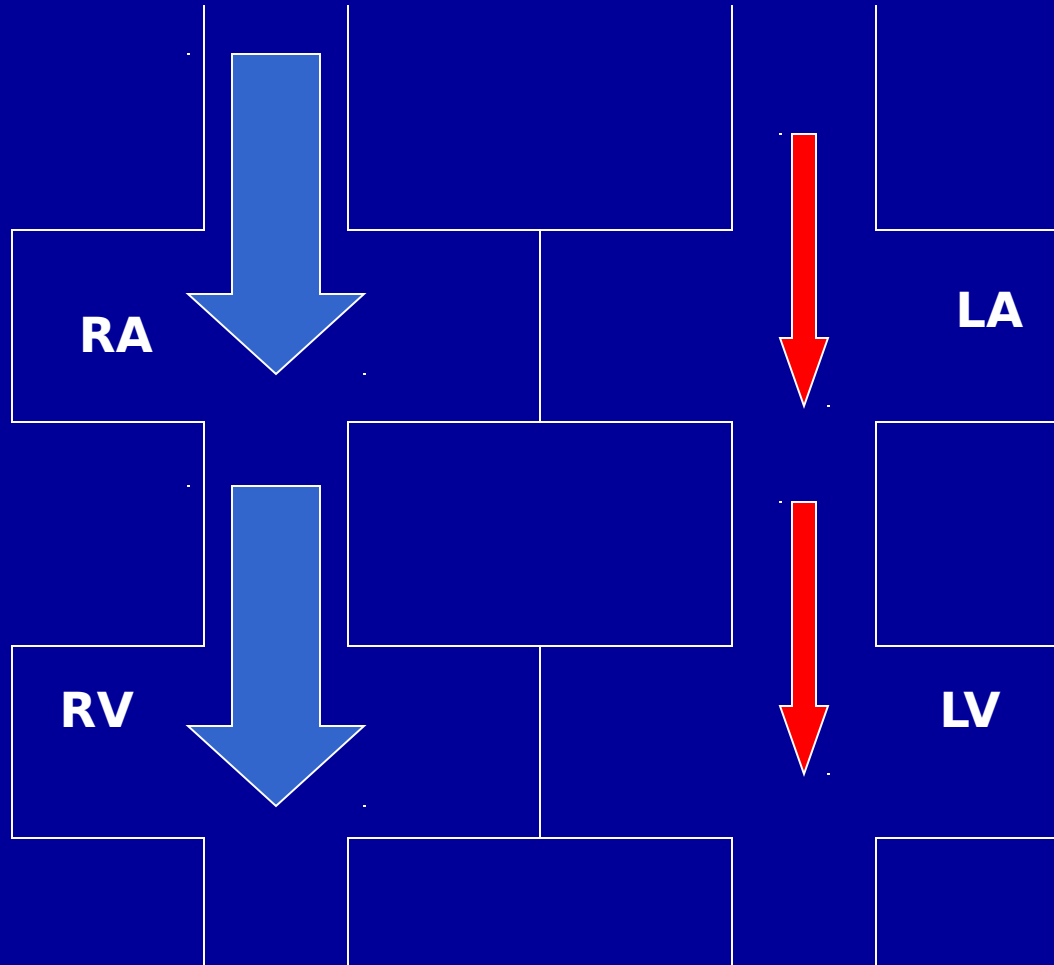
- S2 caused by closure of semilunar valves
  - Aortic
  - Pulmonic
- Two distinct components
  - Aortic closure “A2”
  - Pulmonic closure “P2”
  - Time until P2 varies depending on the time it takes the RV to empty
    - If RV is delayed, P2 will be audibly later than A2 causing “splitting”



# S2 Splitting

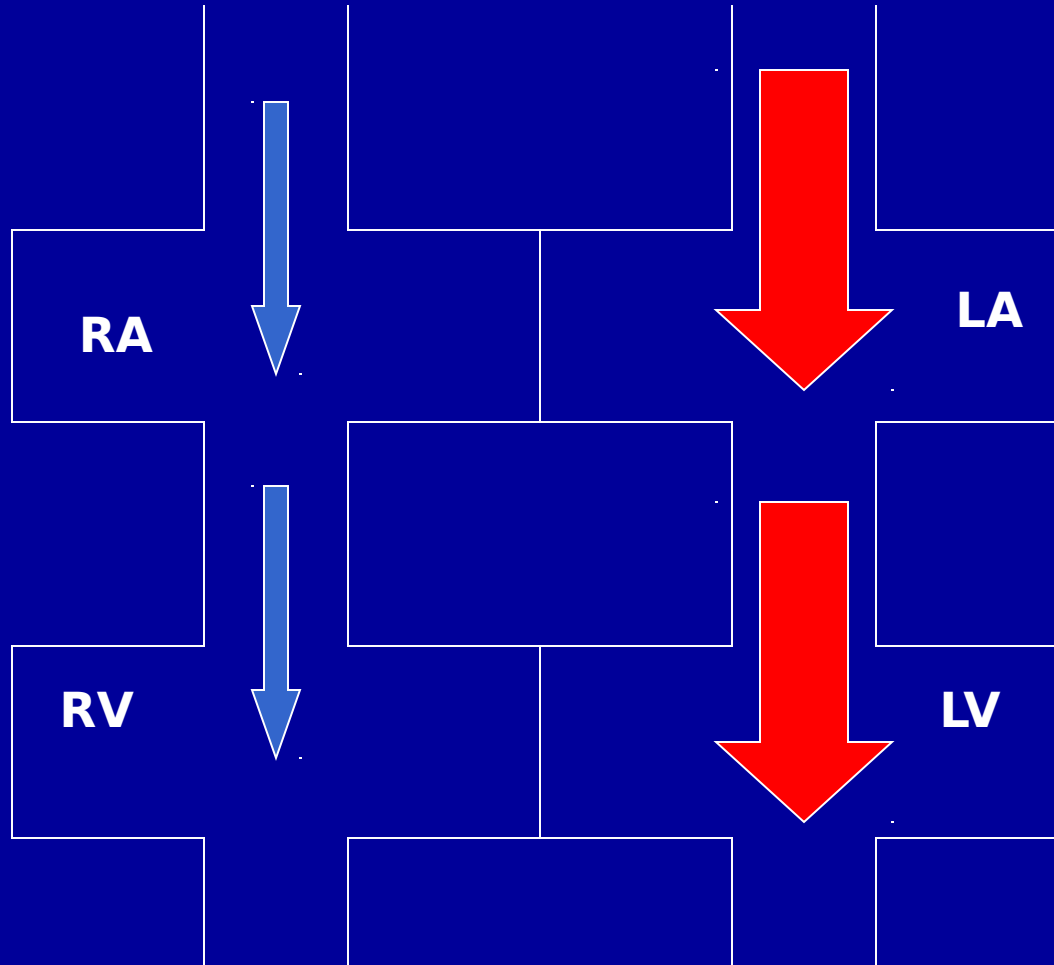
- Inspiration decreases intrathoracic pressure, increases RV filling
- RV is relatively weak, and an increase in filling results in slower emptying
  - Inspiration delays P2, causing audible splitting of S2





Inspiration





Expiration





# Abnormalities of S2

- Loud P2
  - If audible at apex, P2 is TOO LOUD
- Single S2
  - A2 or P2 missing
- Wide splitting of S2
- Paradoxical splitting
  - P2 comes after A2 instead of before





# Loud P2 means pulmonary hypertension

- P. Hypertension
  - Systolic BP in pulmonary artery  $>50$  mm Hg
  - Left heart failure
  - Mitral valve disease
  - Pulmonary arteriolar constriction
  - Pulmonary vessel occlusion
    - Thrombus, tumor, other



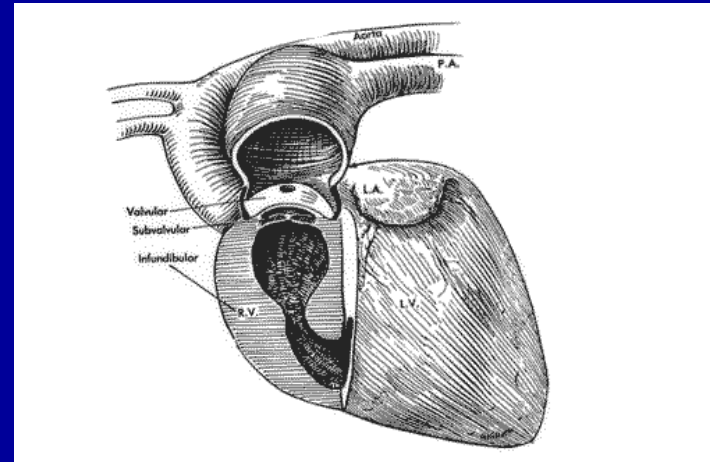
# Widely split S2

- Late P2
  - Delayed activation of RV
    - Right bundle branch block
    - RV overload
      - Pressure
      - Volume
- Early A2
  - Mitral Regurgitation causing rapid emptying



# Pulmonic Stenosis

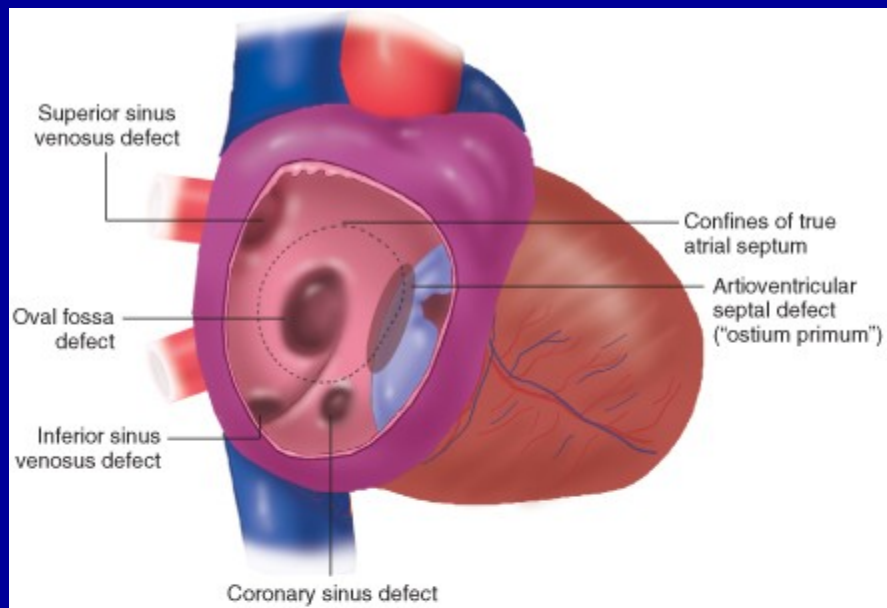
- Obstructs RV emptying
- Pressure overload in RV
- Prolongs RV systole
- Causes widely split S2



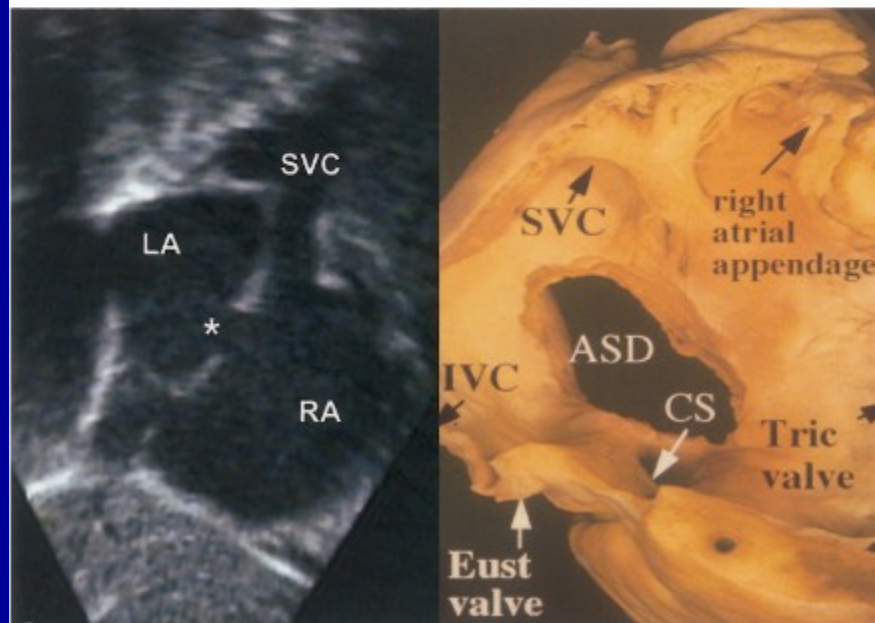
# Atrial Septal Defect

- 1% of population born with hole between LA and RA
- LA blood shunts to RA
- RV volume overload
  - Prolongs RV systole
  - Widely splits S2 due to delay in P2
  - **PERSISTENT, FIXED SPLITTING** of S2
    - Diagnostic of ASD





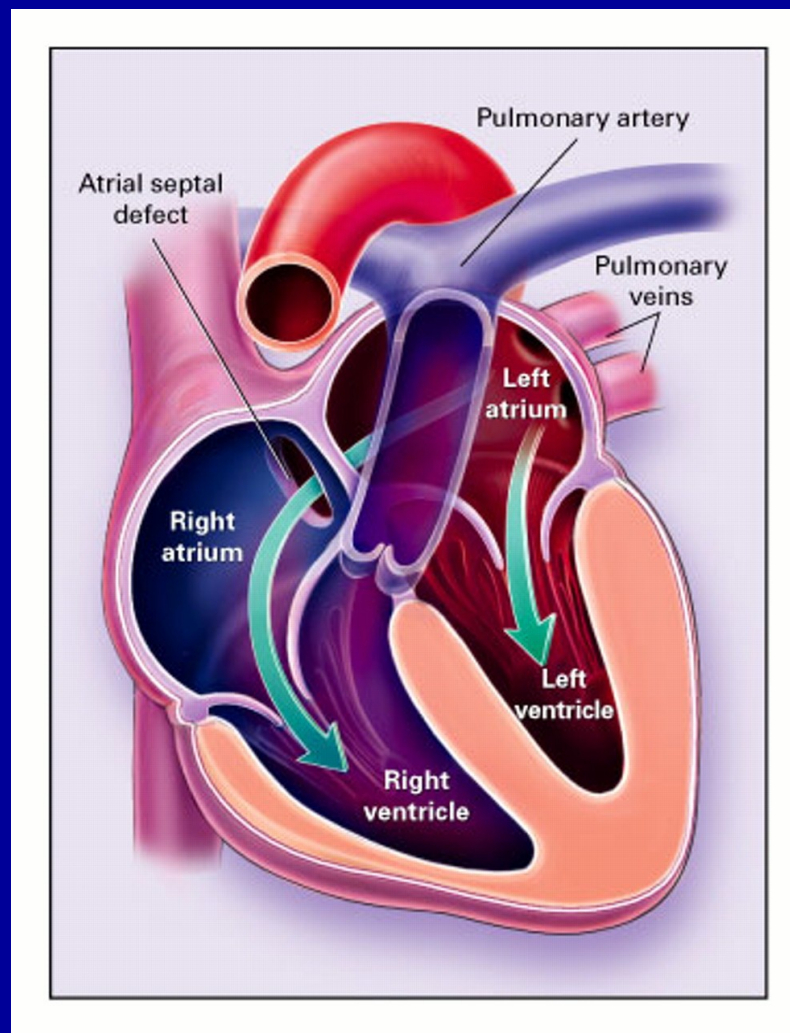
A



B



## Atrial Septal Defect with Resultant Left-to-Right Shunting



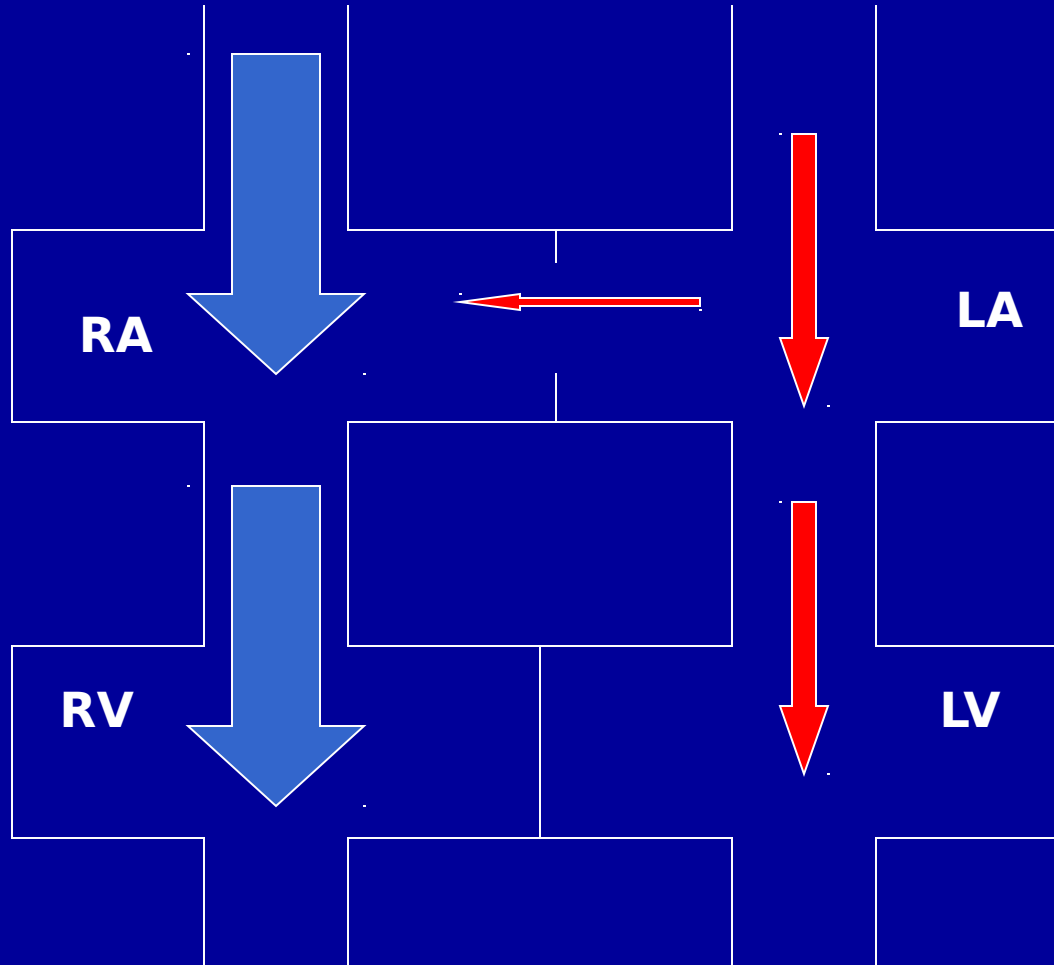
Brickner, M. E. et al. N Engl J Med 2000;342:256-263



The NEW ENGLAND  
JOURNAL of MEDICINE



# Atrial Septal Defect

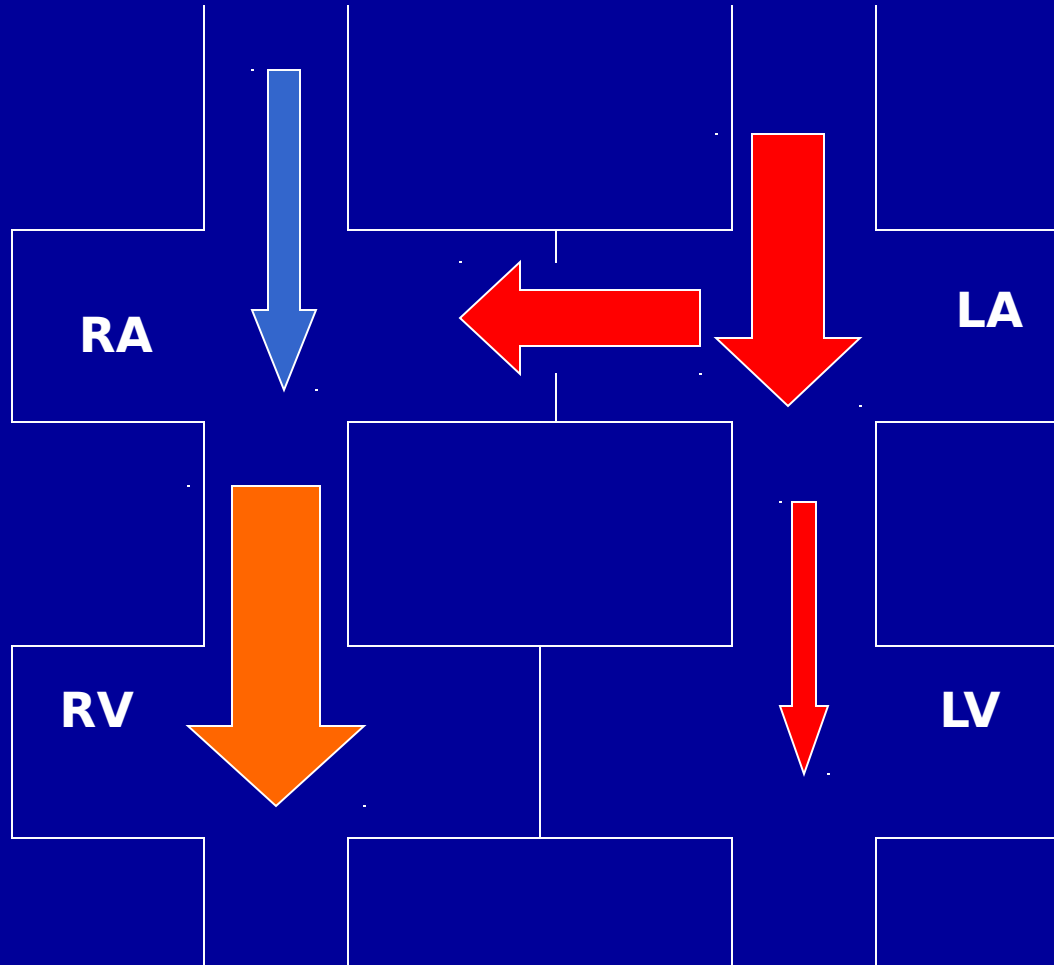


Inspiration





# Atrial Septal Defect



Expiration



# Paradoxical Splitting S2

- A2 is delayed so that it comes after P2
- Split may appear with EXPIRATION, reversing normal pattern
  - Left heart failure
  - Aortic stenosis
  - LBBB
  - PDA
  - Pacemaker



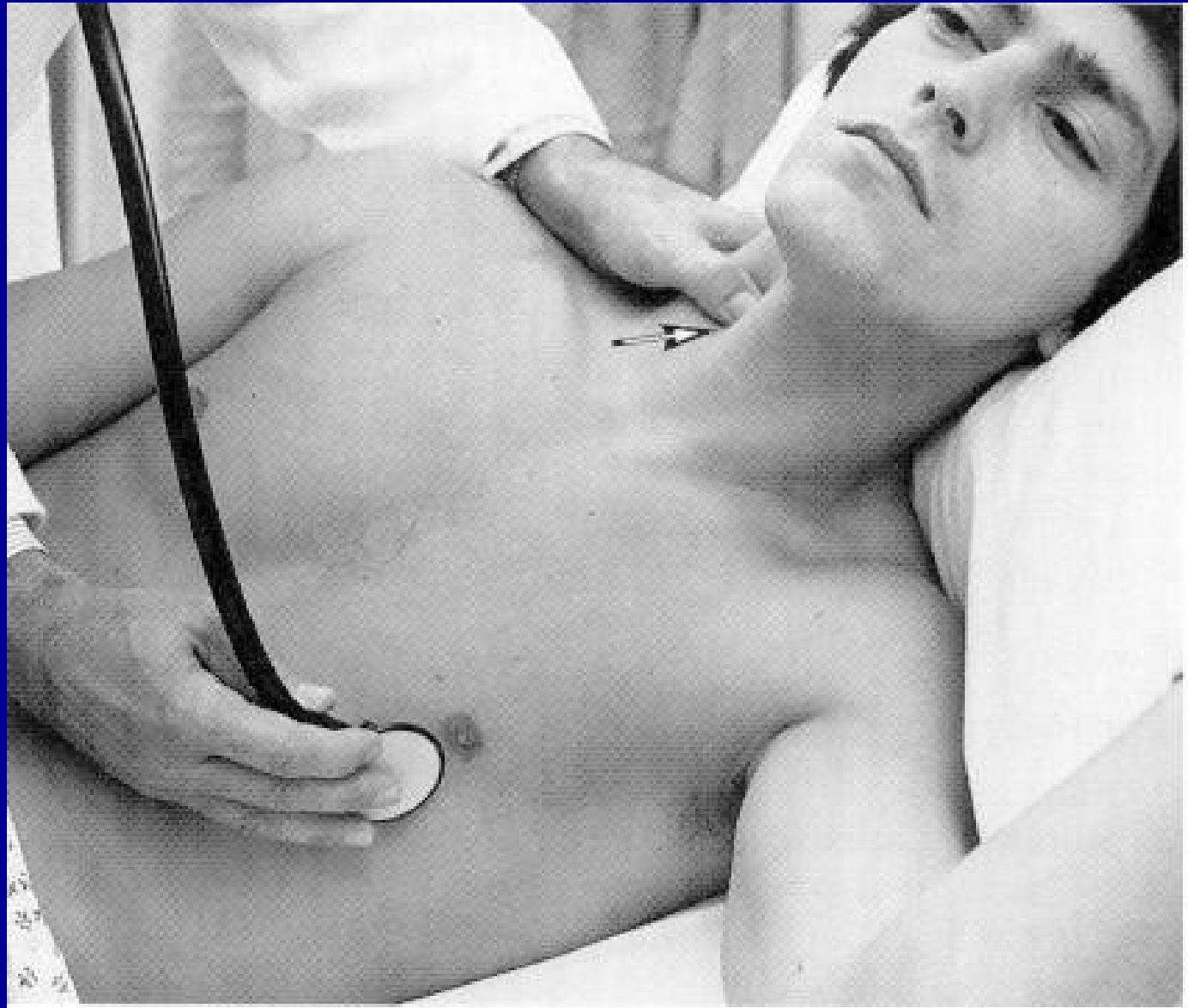


# Diastolic filling sounds

- Low frequency sounds caused by filling of ventricles in diastole
- DIASTOLIC
- “Thud” sound
- Difficult to hear
  - Need to listen with BELL, lightly applied to apex in the left lateral decubitus position
  - Cannot hear with diaphragm

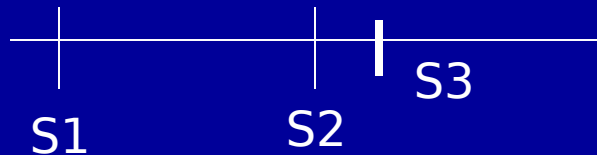


# Left lateral decubitus



# S3

- Follows S2 by 120-160 ms
- Caused by rapid filling phase of diastole
- NORMAL up to 30
  - As heart stiffens with age, disappears
  - In patients with heart disease, typically indicates VOLUME OVERLOAD





# S4

- Precedes S1
- Caused by atrial contraction
  - Blood hitting stiff, noncompliant ventricle
  - Hypertension, Aortic stenosis, LV hypertrophy
- Always abnormal
- Not present in ATRIAL FIBRILLATION



S4 S1 S2



# Stupid mnemonics

- S3
  - KEN\*TUCK'\*Y
  - SHLOSH\*ING IN
- S4
  - TEN\*NES\*SEE'
  - A\*STIFF Heart
- S3 and S4
  - Massachusetts





# Common Pitfalls

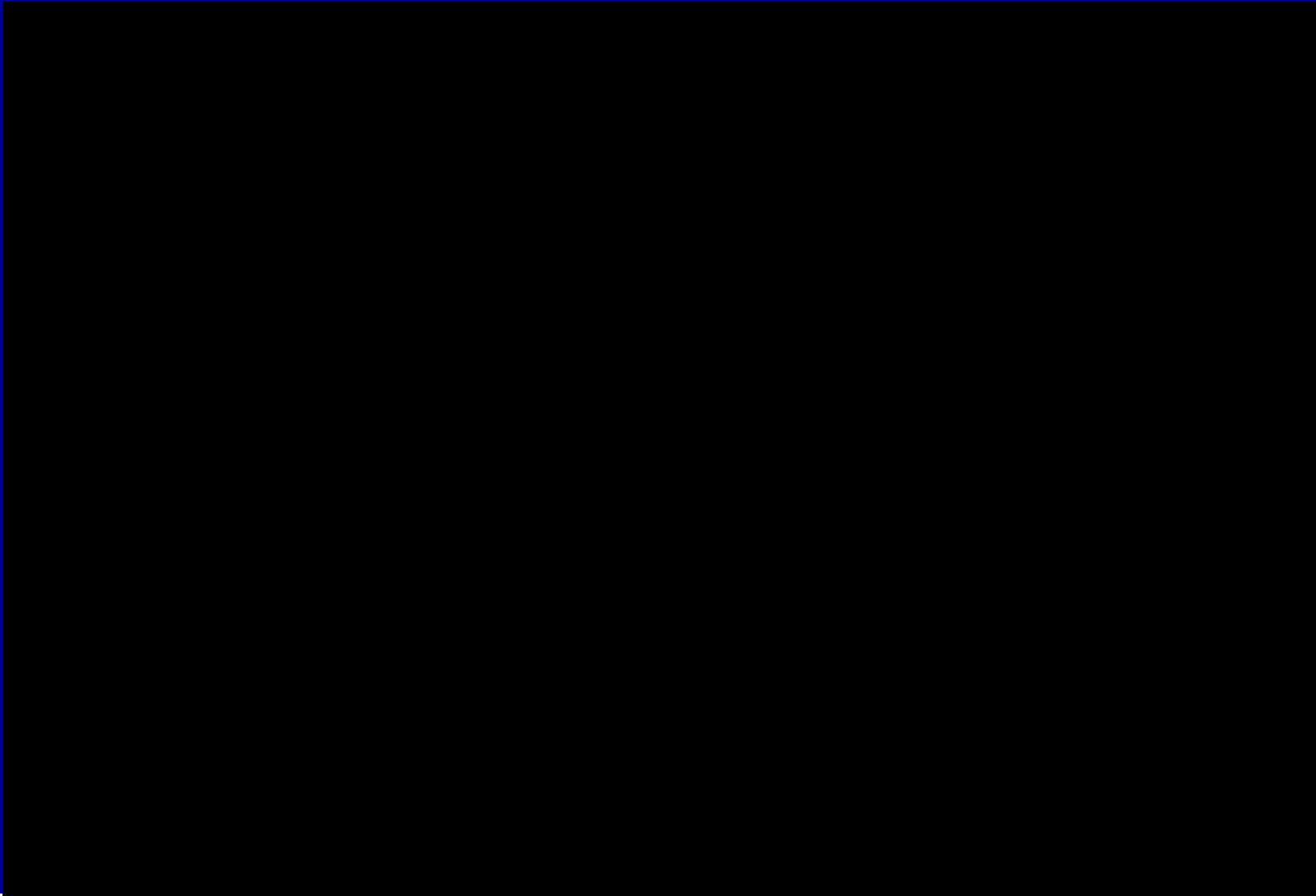
- Split S1
  - High Frequency
  - M1 and T1 intensity similar
  - Located at LLSB, base
- S4, S1
  - Low frequency, S4 only heard with bell
  - S4 subtle, less intense than S1
  - Only heard at apex



# Pericardial Knock

- Caused by diastolic filling of a heart with pericardial calcification
  - TB, radiation, pericarditis, idiopathic
  - Timing similar to S3 but LOUD







# Ejection sounds

- Opening of aortic or pulmonic valve usually silent
- Abnormal valve less compliant, may vibrate when opening
- High frequency sound immediately post S1 usually caused by congenitally abnormal AoV
- May be caused by Aortic or pulmonic dilatation



**Short axis views from  
above aortic valves**

**Left parasternal  
long axis view**

Aortic arch

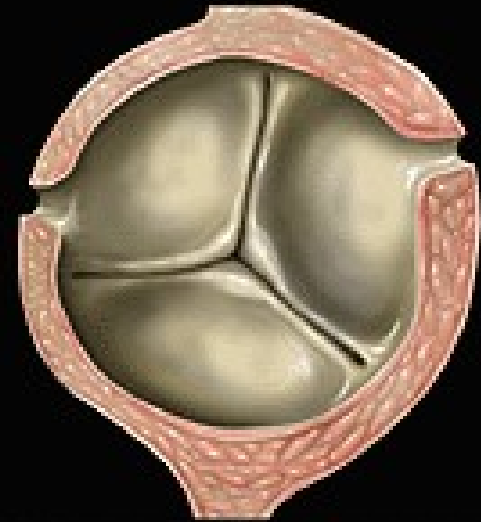
Bicuspid aortic valve

Left  
atrium

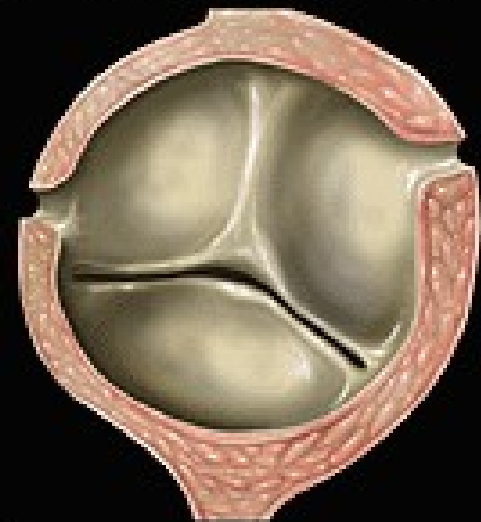
Mitral valve

Left ventricle

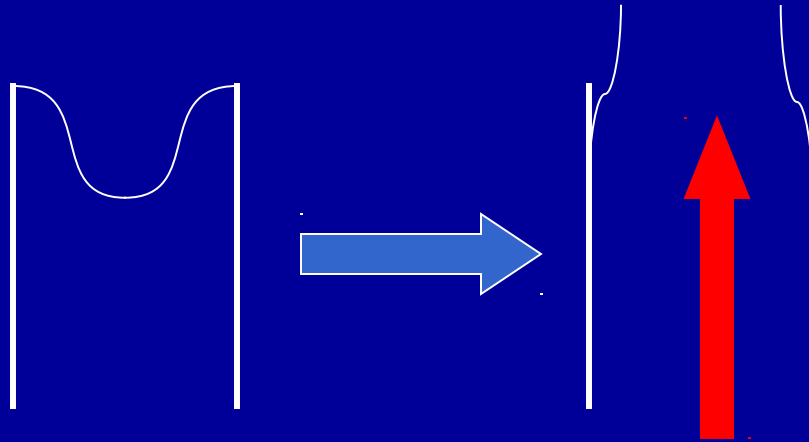
**Normal aortic valve**



**Bicuspid aortic valve**

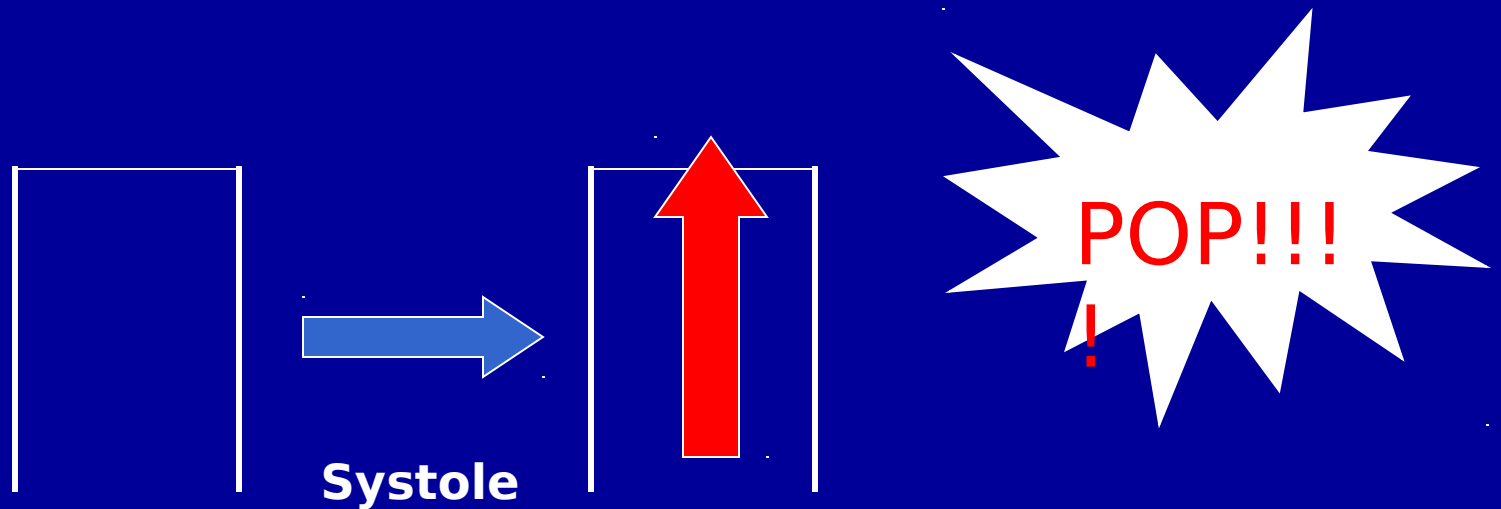






**Normal Systole**





Abnormal Bicuspid valve resists opening until pressure builds in systole, then causes a loud, high frequency vibration called an ejection sound.



# Aortic Ejection Sound

- High Frequency
- No respiratory variation
- Heard over the entire precordium but best at the APEX





# Pulmonic ES

- Frequently present in pulmonic stenosis but can also be heard in pulmonary hypertension
- Varies in timing and intensity with respiration
  - May disappear with inspiration



# Mitral Opening Snap

- High frequency sound caused by opening of a stiff MV in mitral stenosis
- Well heard with diaphragm
- Frequently heard at the aortic area
- A2-OS interval 30-130 ms, unchanged by respiration
- Often the first sign of MS



# Mitral Opening Snap

- Closer the interval between A2 and OS, the greater the pressure in the left atrium
  - Suggest more severe mitral stenosis
- Opening snap is often lost in severe mitral stenosis due to calcification







# Pitfalls

- Split S2
  - P2 only heard in pulmonic region
  - Should cycle with respiration
  - Short interval (40 ms at end expiration)
- A2, OS
  - OS radiates widely
  - A2-OS interval constant
  - >40 ms

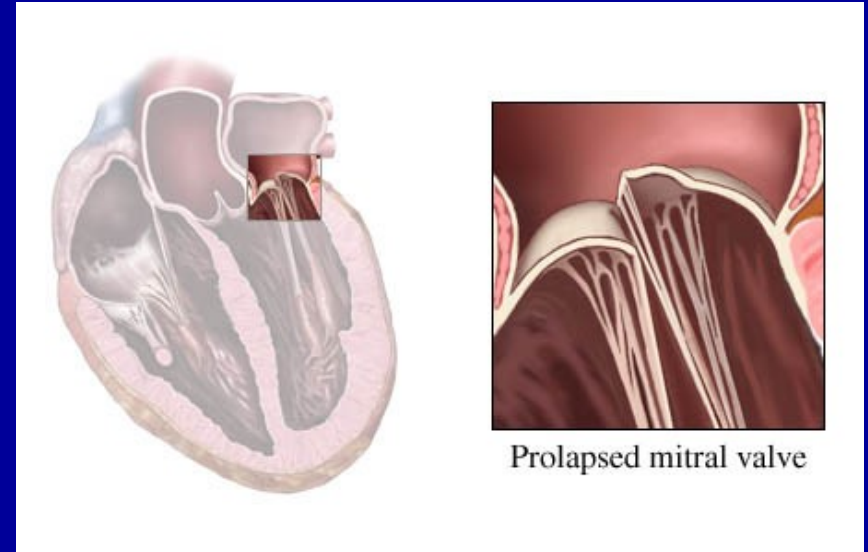
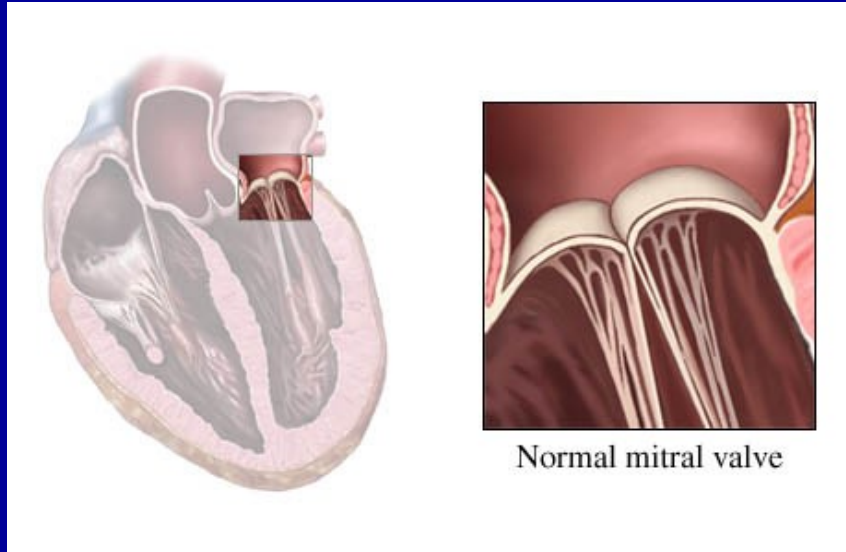


# Pitfalls

- S3
  - Low frequency
  - Only heard at apex
- A2, OS
  - High Frequency
  - OS radiates widely



# Mitral Valve Prolapse



**Movement of mitral leaflet into LA during systole can cause mid systolic “Click” sound**

**High frequency; heard best at apex**

**Changes timing with posture**





# Murmurs

- Murmurs are prolonged in time while sounds are instantaneous
- Result from turbulence
  - Turbulence occurs when laminar flow breaks down
  - excessive acceleration
  - Loss of viscosity



Blood must accelerate to negotiate small apertures





# What if you hear something?

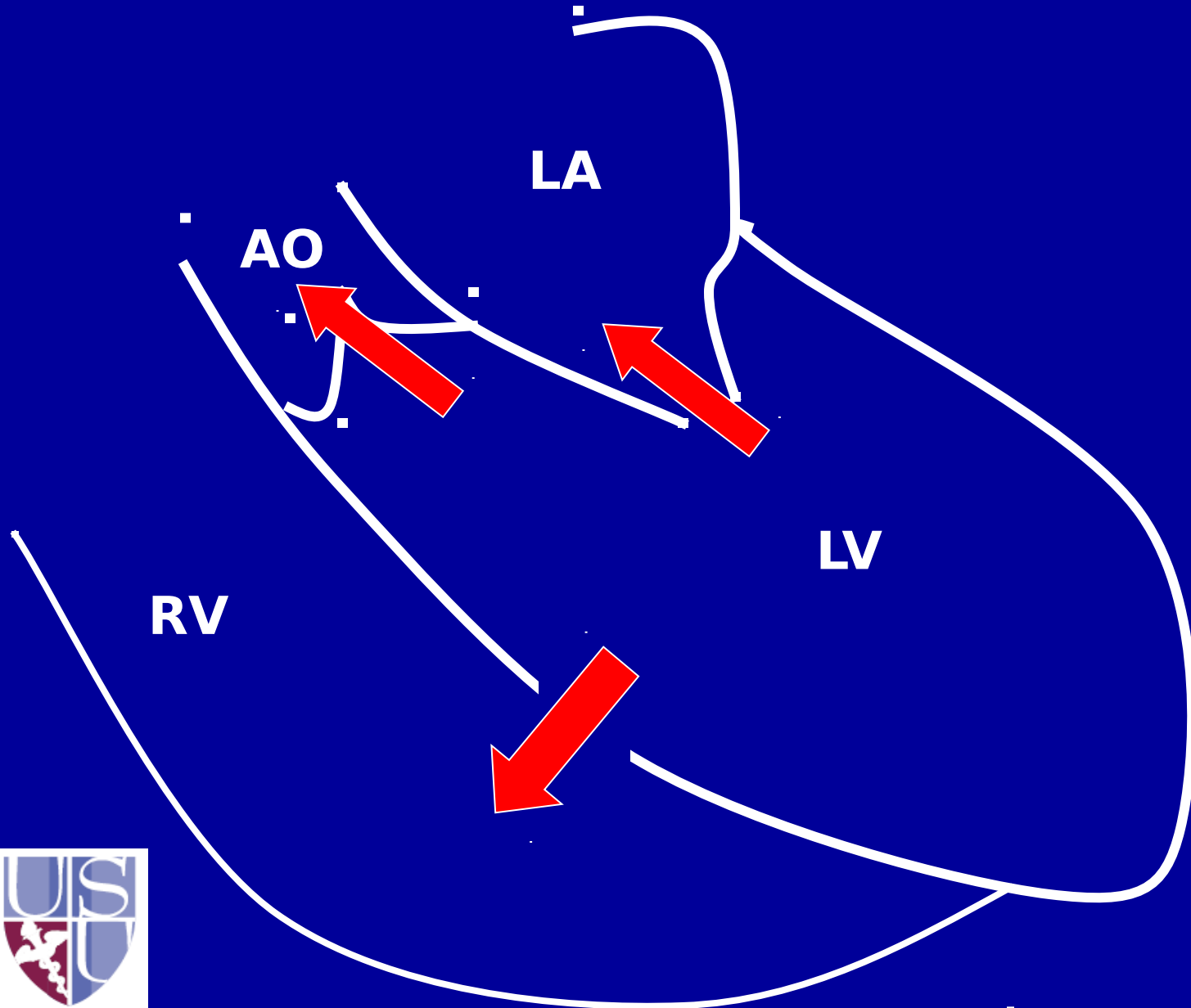
- Is it systolic, diastolic, or both?
  - What is the pattern?
- Where is it loudest?
- Does it radiate?
- Are there other associated findings?
  - S2 splitting normal, loud P2, gallop sound?

• Maneuvers

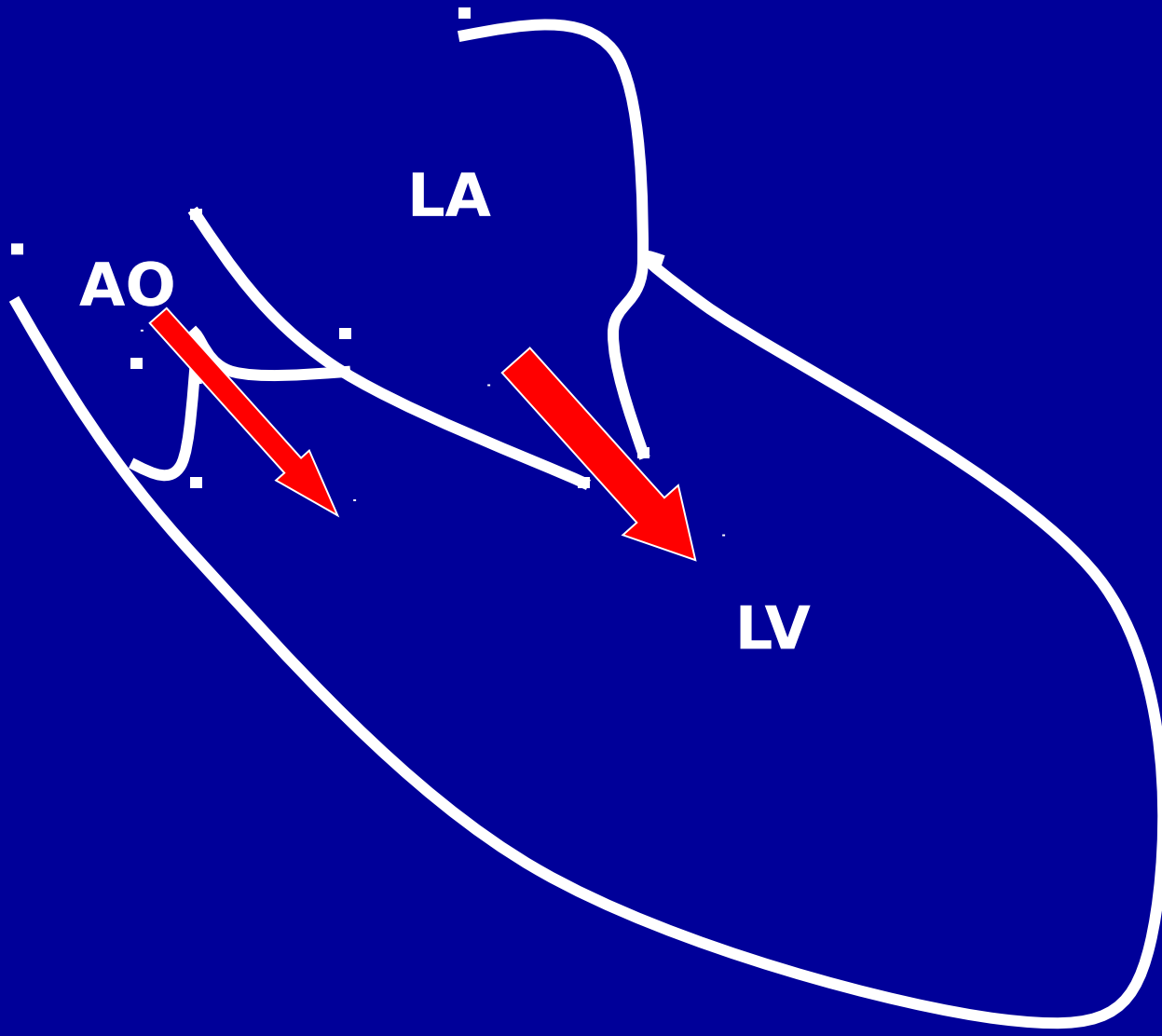




# Systole



# Diastole



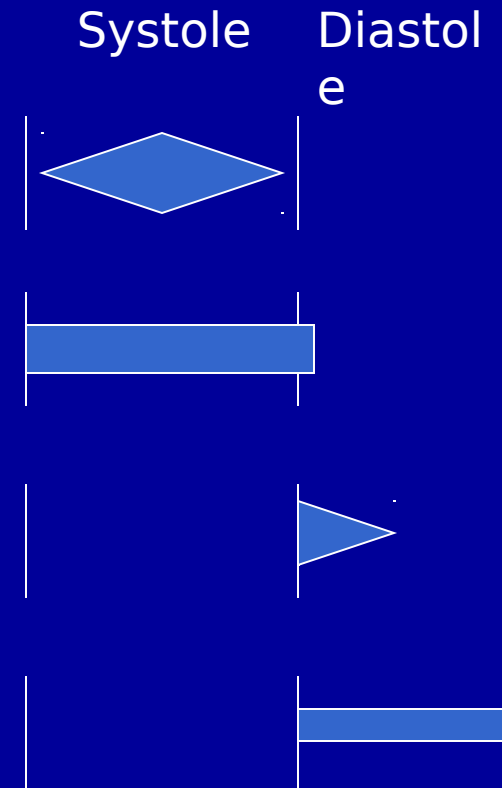
# Grading Murmurs

- Scale one to six
- I/VI murmur is less than S1/S2
- II/VI murmur is equal to S1/S2
- III/VI murmur is greater than S1/S2
- IV/VI murmur is associated with a palpable thrill
- V/VI can be heard with the stethoscope partway on chest
- VI/VI audible with naked ear



# Murmur Patterns

- Common systolic
  - Crescendo-decrescendo
  - Holosystolic
- Common diastolic
  - Decrescendo
  - Holodiastolic



# Radiation of Murmurs

- Murmurs will be heard downstream from source
  - Aortic stenosis radiates to carotids
  - PS to pulmonary artery
  - Aortic regurgitation to the LLSB
  - Mitral regurgitation to the axilla





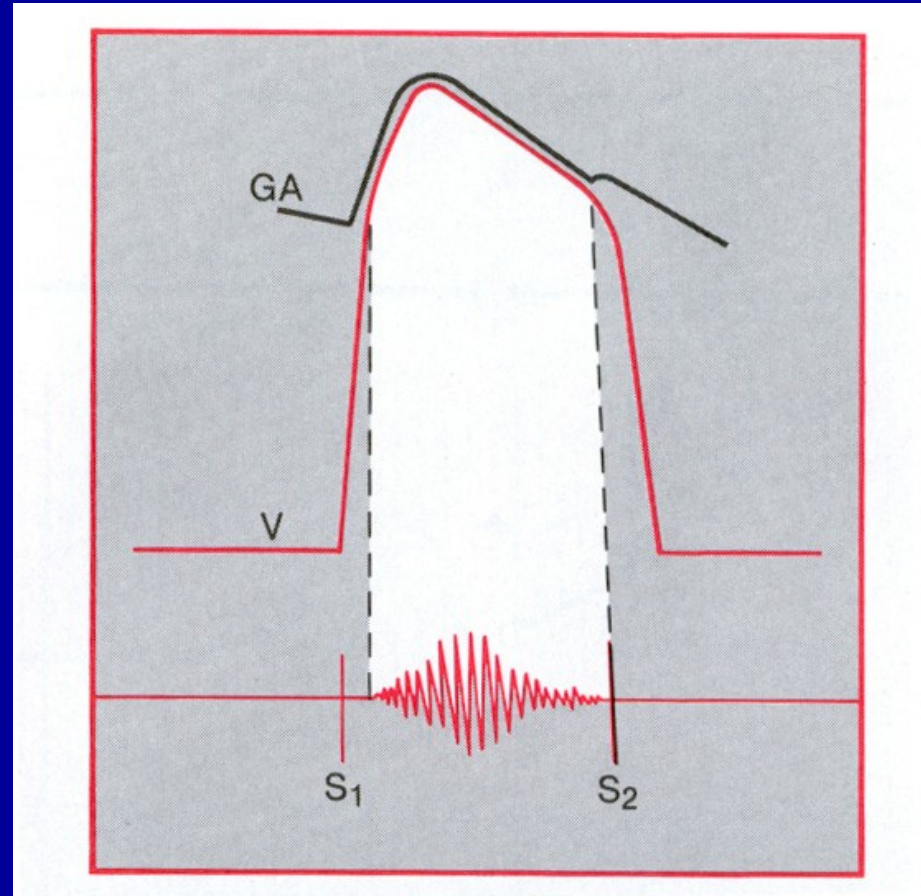
# Mid-systolic Ejection Murmurs

- Caused by turbulent flow out of ventricles
- Increased ejection rate or decreased viscosity
  - Exercise, fever
  - pregnancy, anemia
- Semi-lunar valve narrowing
  - Aortic Stenosis
  - Pulmonic Stenosis
- Intraventricular obstruction
  - Subaortic or subpulmonic



# Mid-systolic Ejection Murmurs

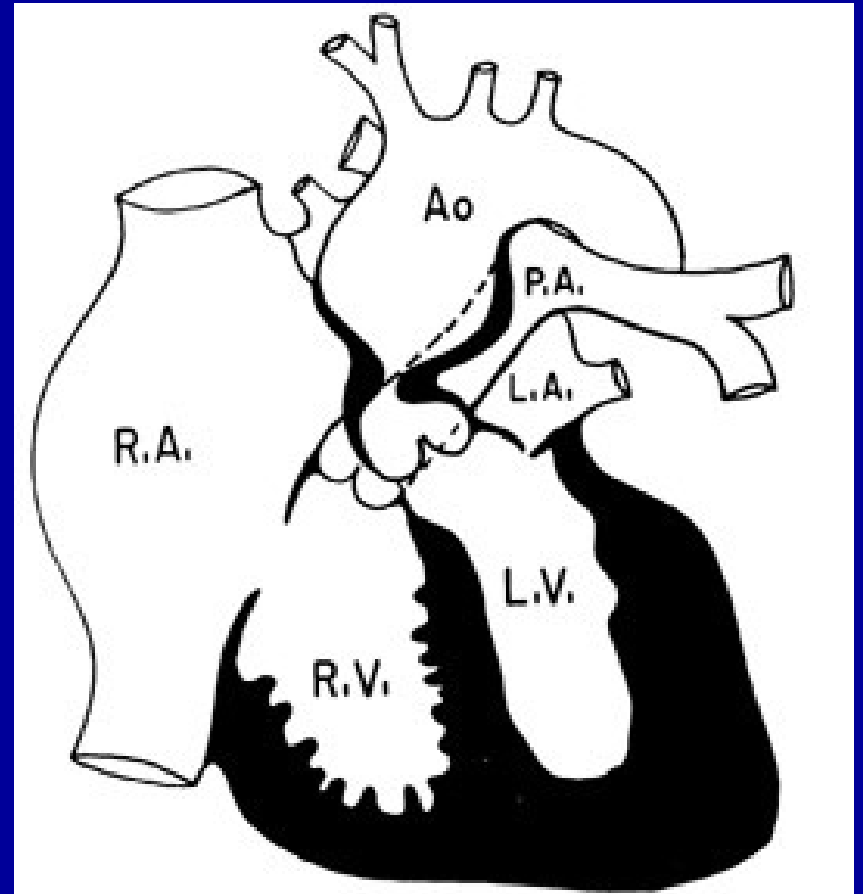
- Crescendo-decrescendo
- High-pitched
- Best heard with diaphragm
- Well-localized

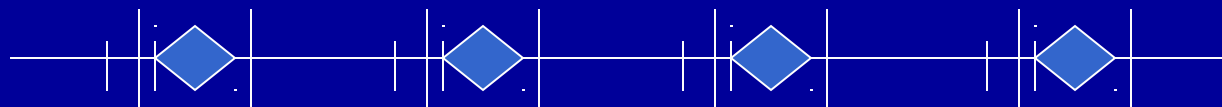
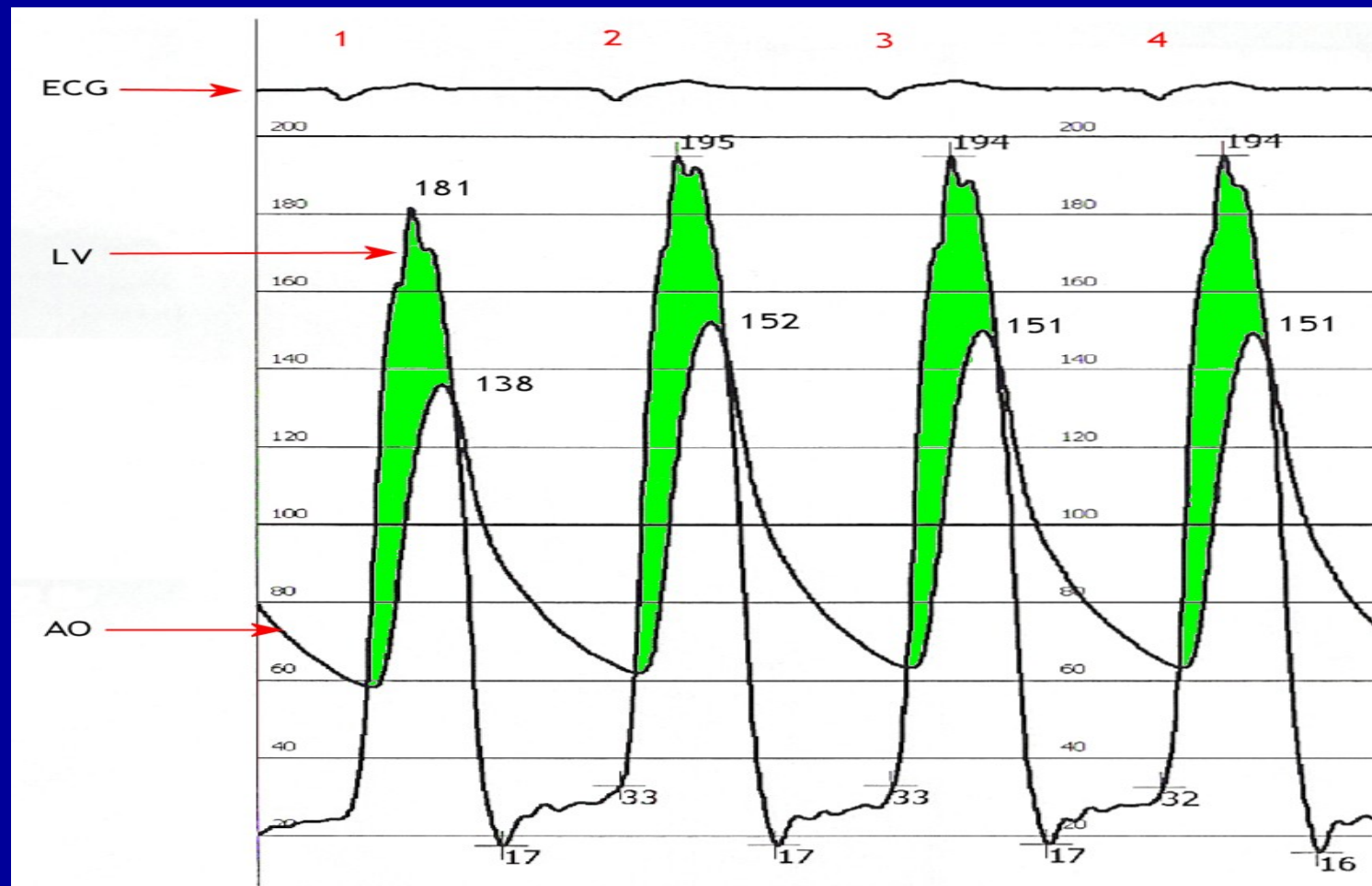




# Aortic Stenosis

- Valvular
- Subvalvular
  - Fixed (membrane)
  - Dynamic (HCM; IHSS)
- Supravalvular





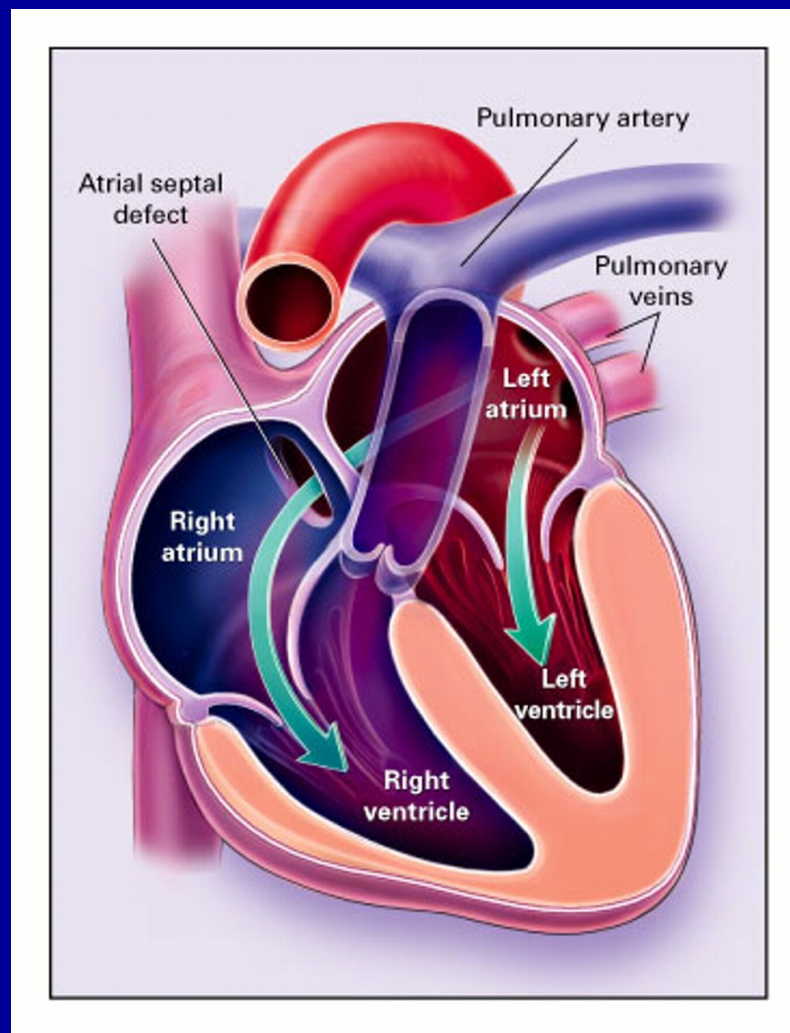
**Valvular Aortic Stenosis**



- Questions?



## Atrial Septal Defect with Resultant Left-to-Right Shunting

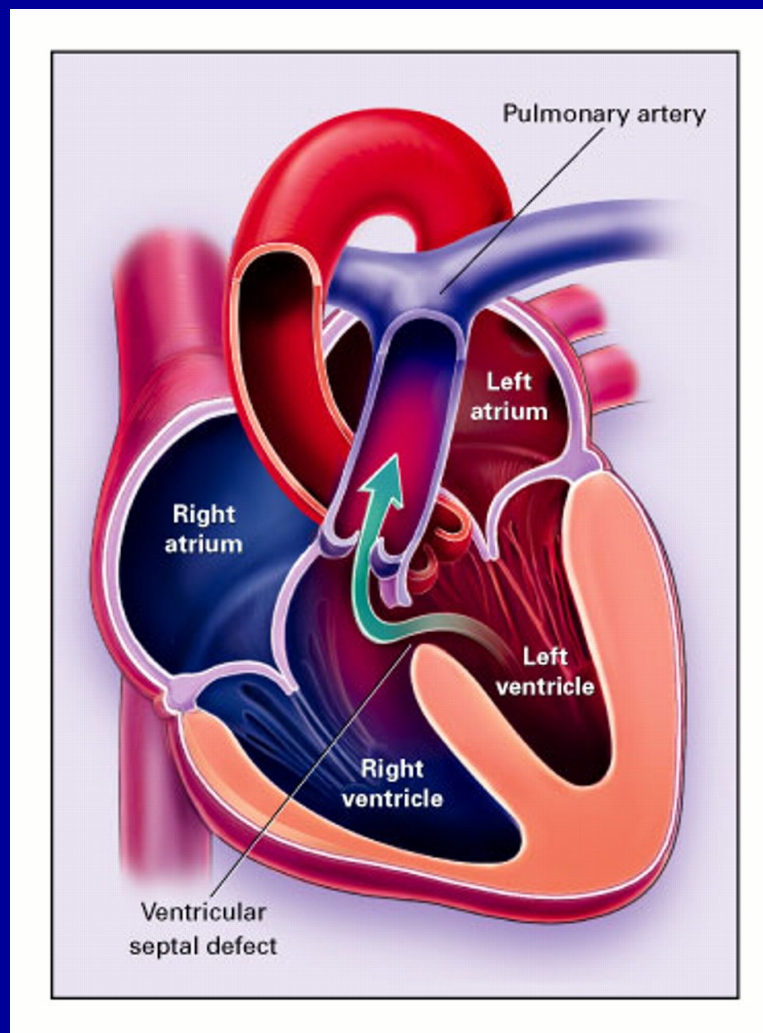


Brickner, M. E. et al. N Engl J Med 2000;342:256-263



The NEW ENGLAND  
JOURNAL of MEDICINE

## Ventricular Septal Defect with Resultant Left-to-Right Shunting

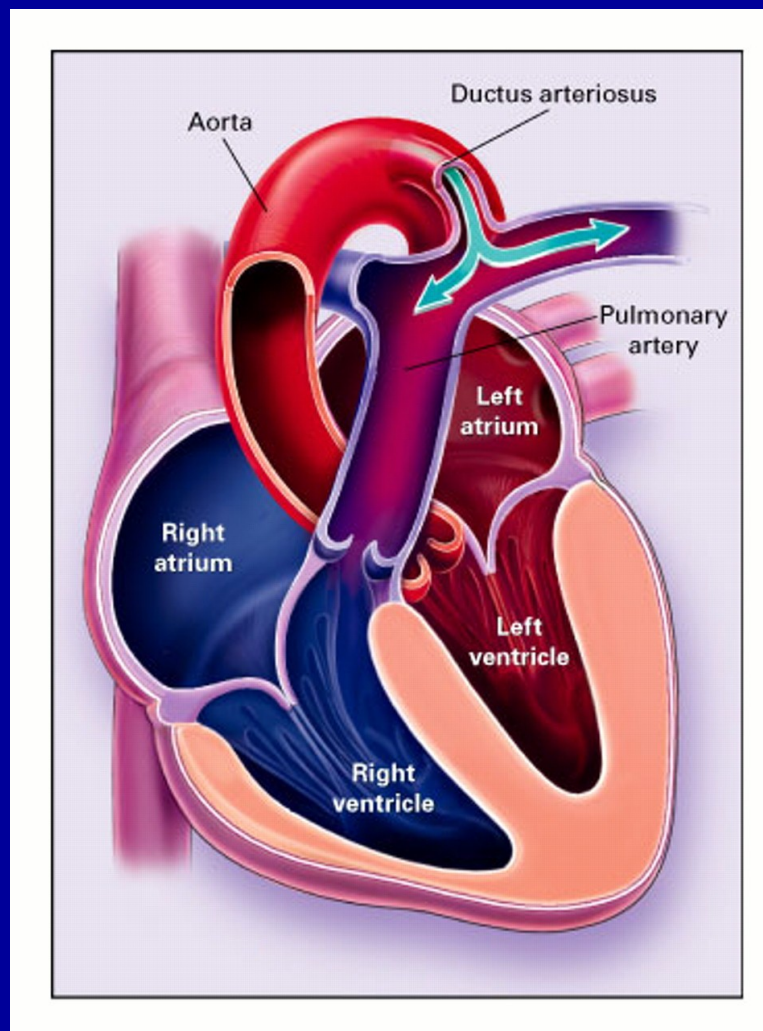


Brickner, M. E. et al. N Engl J Med 2000;342:256-263



The NEW ENGLAND  
JOURNAL of MEDICINE

## Patent Ductus Arteriosus with Resultant Left-to-Right Shunting



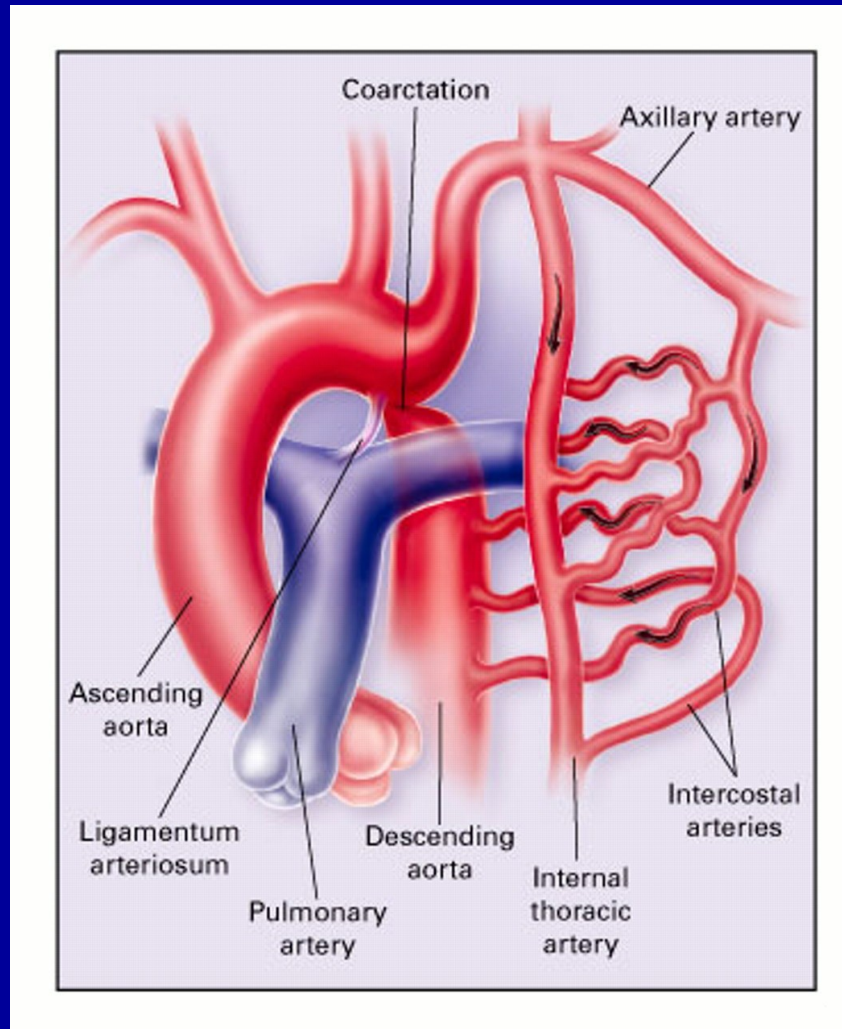
Brickner, M. E. et al. N Engl J Med 2000;342:256-263



The NEW ENGLAND  
JOURNAL of MEDICINE



# Coarctation of the Aorta

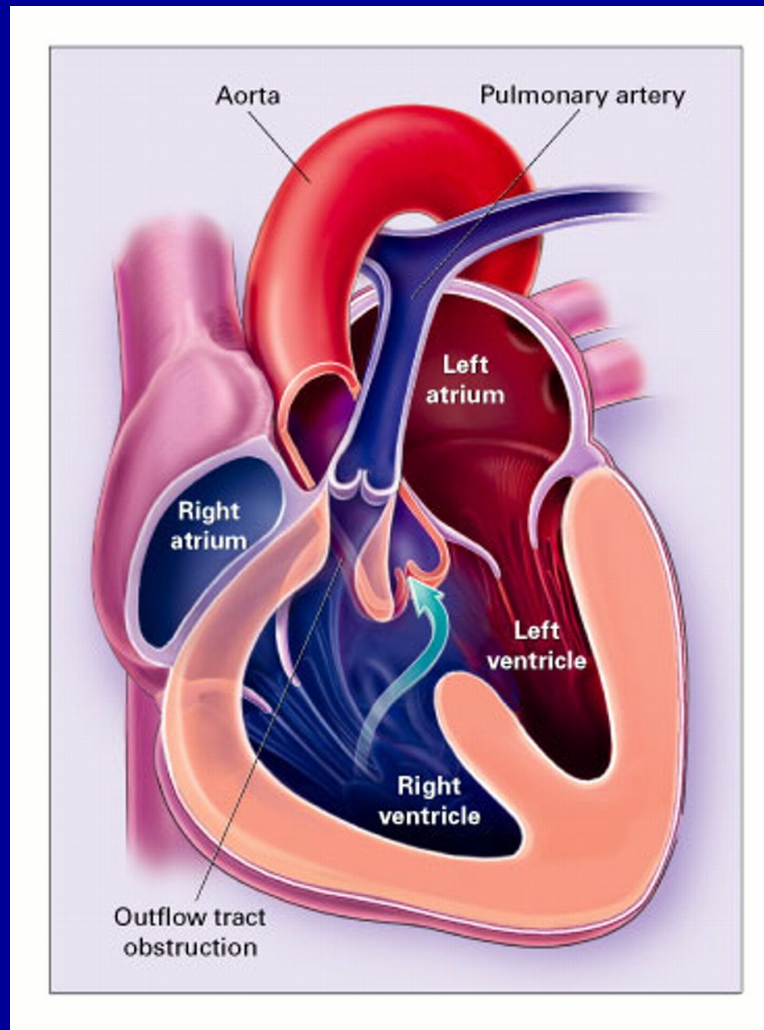


Brickner, M. E. et al. N Engl J Med 2000;342:256-263



The NEW ENGLAND  
JOURNAL of MEDICINE

# Tetralogy of Fallot



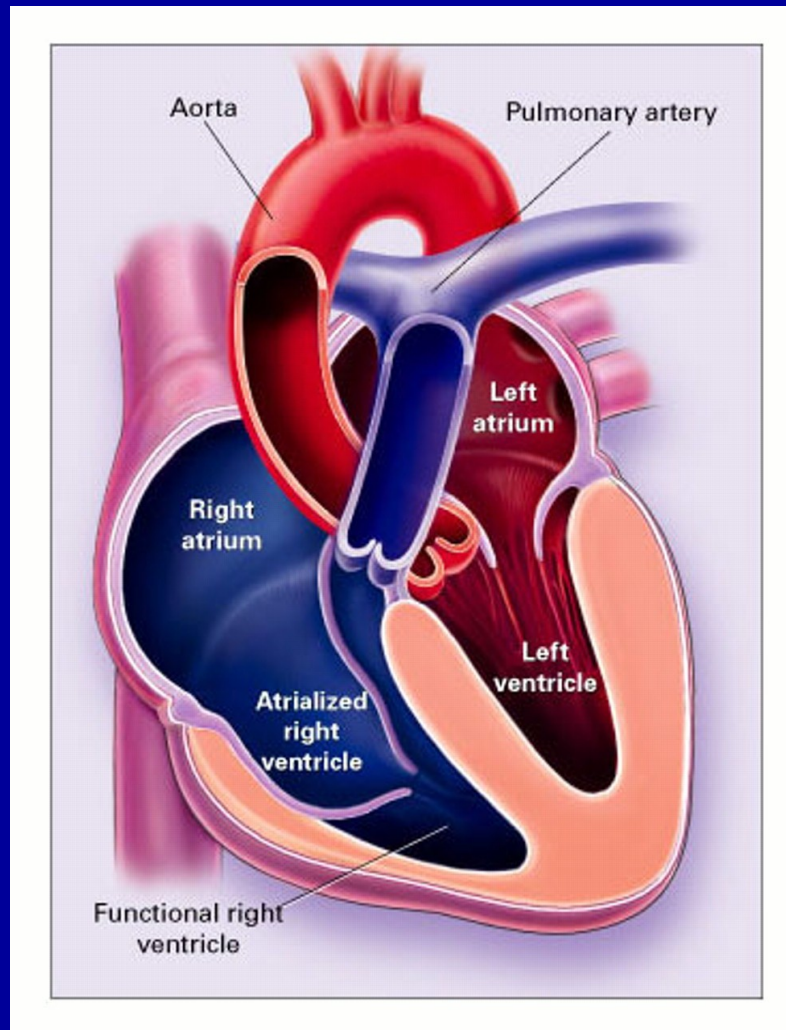
Brickner, M. E. et al. N Engl J Med 2000;342:334-342



The NEW ENGLAND  
JOURNAL of MEDICINE



## Ebstein's Anomaly

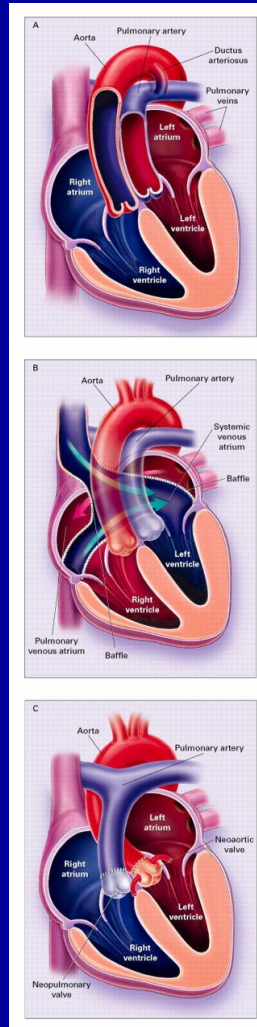


Brickner, M. E. et al. N Engl J Med 2000;342:334-342



The NEW ENGLAND  
JOURNAL of MEDICINE

# Transposition and Switching of the Great Arteries

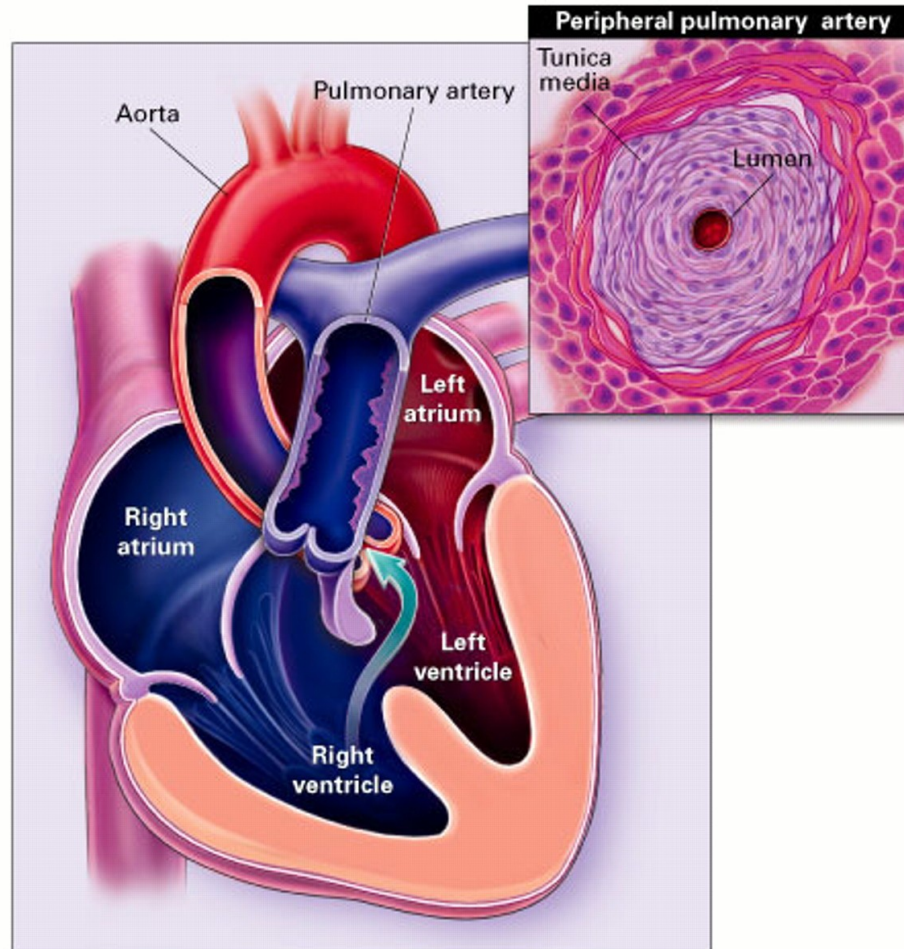


Brickner, M. E. et al. N Engl J Med 2000;342:334-342



The NEW ENGLAND  
JOURNAL of MEDICINE

# Eisenmenger's Syndrome



Brickner, M. E. et al. N Engl J Med 2000;342:334-342



The NEW ENGLAND  
JOURNAL of MEDICINE

# Auscultatory positions

- Four cardinal positions
- Still need to “inch” the stethoscope along the LLSB to apex (or vice versa)

